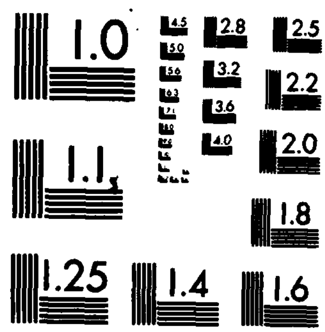
AD-A129 139 DIGITAL IONOSONDE STUDIES AT FORT MONMOUTH NEW JERSEY 1/1
(U) ARMY ELECTRONICS COMMAND FORT MONMOUTH NJ
F J GORMAN ET AL. DEC 77 ECOM-4555

UNCLASSIFIED F/G 20/14 NL

END
DATE
FILMED
DTIC


1.0
4.5
2.8
2.5
5.0
5.6
3.2
2.2
6.3
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

2

Research and Development Technical Report

ECOM - 4555

DIGITAL IONOSONDE STUDIES AT FORT MONMOUTH, N. J.

F. J. Gorman, Jr.
H. Soicher
Communications /ADP Laboratory

December 1977

ECOM

US ARMY ELECTRONICS COMMAND FORT MONMOUTH, NEW JERSEY 07703

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER ECOM-4555	2. GOVT ACCESSION NO. AD-A129139	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Digital Ionosonde Studies at Fort Monmouth, NJ		5. TYPE OF REPORT & PERIOD COVERED Interim, Oct 76-Sep 77
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) F.J. Gorman, Jr., & H. Soicher		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Comm/ADP Laboratory DRDCO-COM-RH-4 Fort Monmouth, NJ 07703		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 611101.91A.33.11.03
11. CONTROLLING OFFICE NAME AND ADDRESS Comm/ADP Laboratory DRDCO-COM-RH-4 Fort Monmouth, NJ		12. REPORT DATE December 1977
		13. NUMBER OF PAGES 9
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution A: Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

HF frequency management;
Digital ionosonde;
Ionospheric drift studies;
HF direction finding;
HF field strength.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Recent developments in the area of digital ionosondes and computer technology have enabled systems to be developed in which virtual heights and echo amplitudes obtained may be translated directly into true height profiles, sky maps and frequency management charts.

Real time ionogram evaluation will enable users to make highly accurate judgements as to the proper selection of frequencies for short and long range HF communications. Libraries of previous ionograms make ionospheric predictions

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

considerably more accurate. The spectral analysis of data taken utilizing an array of receiving antennas allows the user to spatially locate traveling ionospheric disturbances. This system gives the specific location of the echo's reflecting surface and its motion with respect to the user's position.

CONTENTS

FIGURES

DIGITAL IONOSONDE STUDIES AT FORT MONMOUTH, NEW JERSEY

INTRODUCTION

Because of the complexity and variability of the ionosphere, extensive measurements and the evaluation of many geophysical parameters are necessary for the understanding of dynamic effects. Much data analysis and classification must precede attempts to explain trends and variations. Gathering the multidimensional information requires sophisticated, reliable measuring instruments and systems. The Digisonde (Digital Ionospheric Sounding System consisting of an on-line computer, drift attachment and auxiliary equipment) determines overhead ionospheric structure in real time. It also has the capability of determining relative amplitude and phase information of its emitted signals.

The ionosonde has a single quartz crystal oscillator as a source for all generated frequencies. Phase coding of the selected transmitted pulse will unambiguously select ionospherically reflected echos. Variable height resolution, coherent detection, large dynamic range are programmable either locally or remotely by a computer.

Data processing within the ionosonde permits the display of transit time with an accuracy of 1.5 km [1] and the echo amplitudes can be measured and displayed to an accuracy of 1 dB. These amplitudes can be used for absorption measurements, and the ionosonde can also operate at a fixed frequency for special studies such as an interferometric system at which incidence angles can be measured as a function of time.

An integral part of the ionosonde system is a chassis which processes conventional ionograms. Raw ionograms are fed into what is known as the Automatic Ionogram Compression and filtering unit. Each transmitted frequency is evaluated and a unique reflecting layer height determined. The echo's amplitude at that height is also displayed. This listing of frequencies, heights and amplitudes is then fed directly into the computer. It is also displayed on a printer in a conventional ionogram format as well as structured in such a way that it can later be presented for frequency management studies.

The computer referenced here, is considered to be a general purpose mini-computer and an ideal choice for on-line real time analysis. The program used in the computer utilizes the lamination technique devised by Jackson. [2] Each layer is divided into a series of laminations, each having its own set of parameters. The rate of change of slope is considered constant throughout each lamination. The profile is a parabola in either plasma frequency or a natural logarithm of plasma frequency.

---

1 Bibl, K., et al., "Digital Ionosondes for Monitoring the Ionosphere," AFCRL-71-0507, 1971.

2 Jackson, John E., "The P'(f) to N(h) Inversion Problem in Ionospheric Soundings," Goddard Space Flight Center," Greenbelt, Maryland, 1971.

Frequency management charts are displayed by playing back long term records of compressed and reformatted ionograms that the Automatic Ionogram and Compression and filtering unit has stored on magnetic tape. The E-layer and F-layer are evaluated independently and displayed side by side on printer. In this type of display, echo amplitudes and frequencies are plotted as a function of time. This record yields a convenient display for frequency selection in the case of a user requesting assistance for a choice of optimum transmitting frequency for his communication equipment. Thus, the least attenuated signal can be determined. The ionosphere is probed continuously at short intervals and the optimum communication frequency is determined. The effects of gravity waves and other phenomena on this optimum frequency is determined.

The installation of a drift attachment introduces a new technique under which four closely spaced antennas can be positioned such that inhomogeneities and motions in the ionosphere can be measured. The main features of this development are the recording of phase as well as the signal amplitude and the introduction of complex spectral analysis. It is now possible to describe the various components of a signal reflected by the ionosphere in terms of their angle of arrival and Doppler Shift of individual components. In contrast to this, an ionogram pictures the average signal delay of the various components as a function of frequency. It can be easily visualized that a combination of the ionosonde with the updated drift technique has significant advantages for research as well as for practical purposes. This type of program will yield the true height of each reflecting layer as well as its specific location within the ionosphere. The picture will also be dynamic in the sense that it will be updated periodically. Thus, motions of reflecting layer will be tracked as it passes over the ionosonde sight.

The drift attachment scans four antennas and includes an on-line multichannel spectrum analyzer. The complex spectrogram data of the four antennas reflection points for each spectral line window within which sufficient coherent energy has been reflected.

DATA

The following figures graphically display examples of data collected at Fort Monmouth. These figures are typical of the data recorded over the last year of continuous operation at our field site.

An example of an ionogram as it is recorded by the ionosonde and then processed by the Automatic Ionogram Comparison and filtering unit (AIC) is shown in Figure 1. This ionogram was taken at 1430 EST on 23 Oct 77. The echo amplitudes are displayed by numbers indicative a 1 dB difference in signal strength. Every 10 frequency steps a preface line indicates time of day, day of year, frequency coverage and receiver settings. In this particular case, the ionogram covers a range of frequencies from 2 to 8 MHz. In the raw ionogram, there are echos at various altitudes. The most significant feature of the cleaned ionograms is that it assigns one unique altitude for each transmitted frequency.

The cleaned ionogram is then fed into the computer. The computer translates the virtual height information into the true height of each reflecting layer. Figure 2 is a copy of the computer printout of an ionogram. There is a listing of virtual heights and frequencies at the beginning of the

printout. The computer then tablulates the frequencies, electron densities and the true height of each reflecting layer.

Figures 3 and 4 are printouts of compressed ionograms covering two separate time periods. Figure 3 — March 22 through March 28, 1977, and Figure 4 — September 21 through September 26, 1977. The E-layer and F-layers are displayed separately. The echo amplitudes and frequencies are displayed as a function of time. The diurnal behavior of the ionosphere is clearly projected. Critical frequencies in the F-layer varies from 2 to 8 MHz. Each vertical line is a specially formatted ionogram, and a new ionogram is initiated every 15-minutes during this period.

By viewing these charts it is clear which frequencies would give optimum communication performance. Each echo is displayed with its amplitude indicated by number whose signal strength differs from an adjacent by 1 dB. It is apparent that frequencies that yield the strongest echo amplitude would be optimum for communication channels. Predictions are possible by studying libraries of previous ionograms.

FUTURE EXPERIMENTS

The Drift System presently operates on an off-line basis. Spectral evaluation of echos from the antenna array will be fed directly into the on-line mini-computer. At the present time, sky maps are generated off-line on a large computer. There is an active program underway which will enable this evaluation to take place in real time.

A program for real-time ray tracing is also underway. Real time calculations of transmission paths through the ionosphere for various elevation angles will be incorporated into the ionosonde facility.

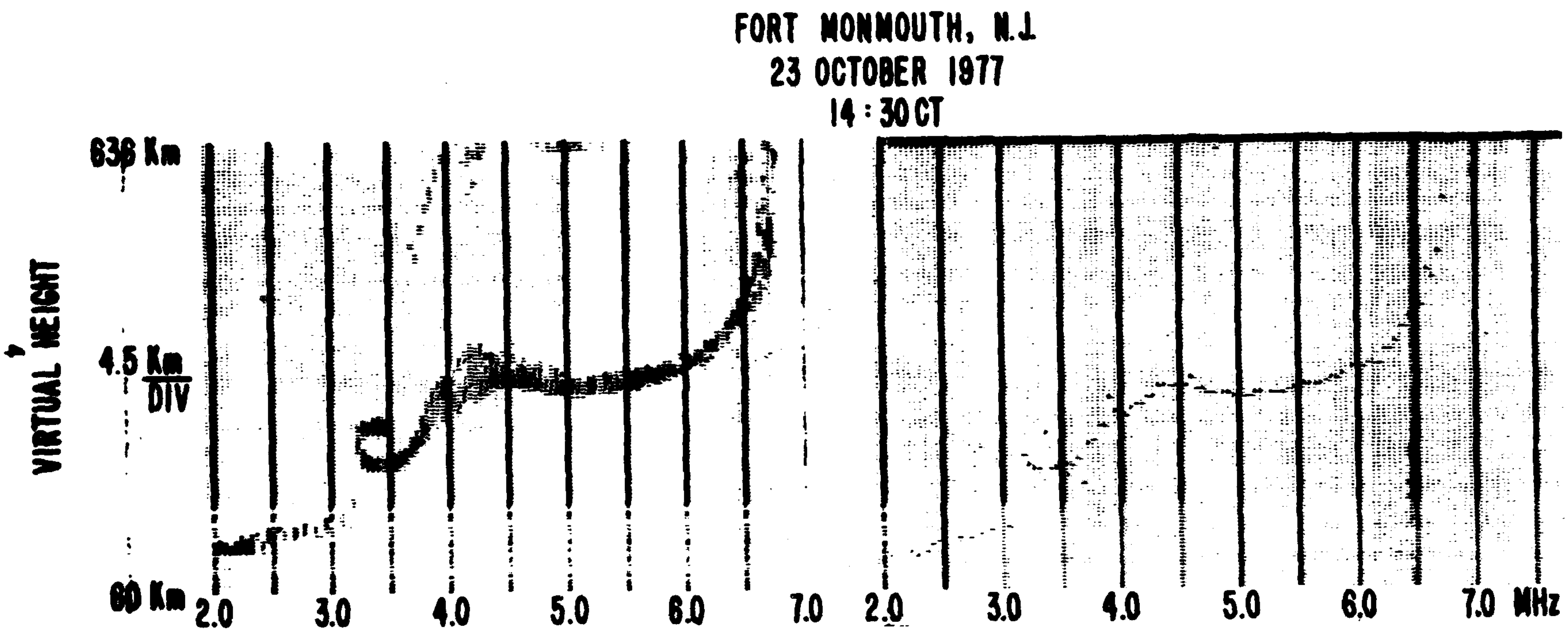


Fig. 1

Raw ionogram (left) and processed ionogram (right), 23 Oct 77, 1430 EST.

ANALYSIS OF IONOGRAMS AT FT. MONMOUTH

INVERSE CUBE, PARABOLIC IN LOG (N)

INPUT DATA

YEAR 1977 MONTH 10 DAY 19 LOCAL STANDARD TIME 1240 DAY NO. 293

DEPTH OF E-VALLEY = 0.20 MHZ

O TRACE

F	HP	F	HP	F	HP	F	HP	F	HP
0.284	80.0	1.500	102.0	1.750	110.0	2.000	112.0	2.500	115.0
3.000	125.0	3.260	172.0	3.320	280.0	3.400	248.0	3.500	235.0
3.700	232.0	3.900	238.0	4.100	240.0	4.300	248.0	4.500	250.0
5.000	255.0	5.500	255.0	6.000	257.0	6.500	262.0	7.000	265.0
8.000	280.0	9.000	305.0	10.000	335.0	11.000	385.0	11.700	430.0

DIP AND FHS AT 80. KM COMPUTED FROM FIELD G.

DIP= 68.9839 FHS= 1.4968 DLAT= 40.2500 DLONG= -74.0600

F	ELCC	HEIGHT
0.2840	1000.1345	80.0000
1.50000	27900.0000	94.9975
1.75000	37975.0000	97.6356
2.00000	49600.0000	99.8549
2.50000	77500.0000	103.3947
3.00000	111600.0000	107.9155
3.26000	131782.2344	115.7691
3.32000	136677.7656	134.6002
3.40000	143344.0000	138.3937
3.50000	151900.0000	142.2444
3.70000	169756.0000	149.1712
3.90000	188604.0156	155.4240
4.10000	208444.0000	161.2370
4.30000	229276.0156	166.7542
4.50000	251100.0000	171.9912
5.00000	310000.0000	183.0253
5.50000	375100.0000	191.6675
6.00000	446400.0000	198.5058
6.50000	523900.0000	204.5660
7.00000	607600.0000	210.0488
8.00000	793600.0000	220.5818
9.00000	1004400.0000	232.5402
10.00000	1240000.0000	246.6302
11.00000	1500400.0000	264.5140
11.70000	1697436.0000	280.3761

CALCULATION OF HMAX AND NMAX ASSUMING PARABOLIC PEAK OF THE FORM

N = NMAX(1-(H-HMAX)(H-HMAX))/CONSTANT

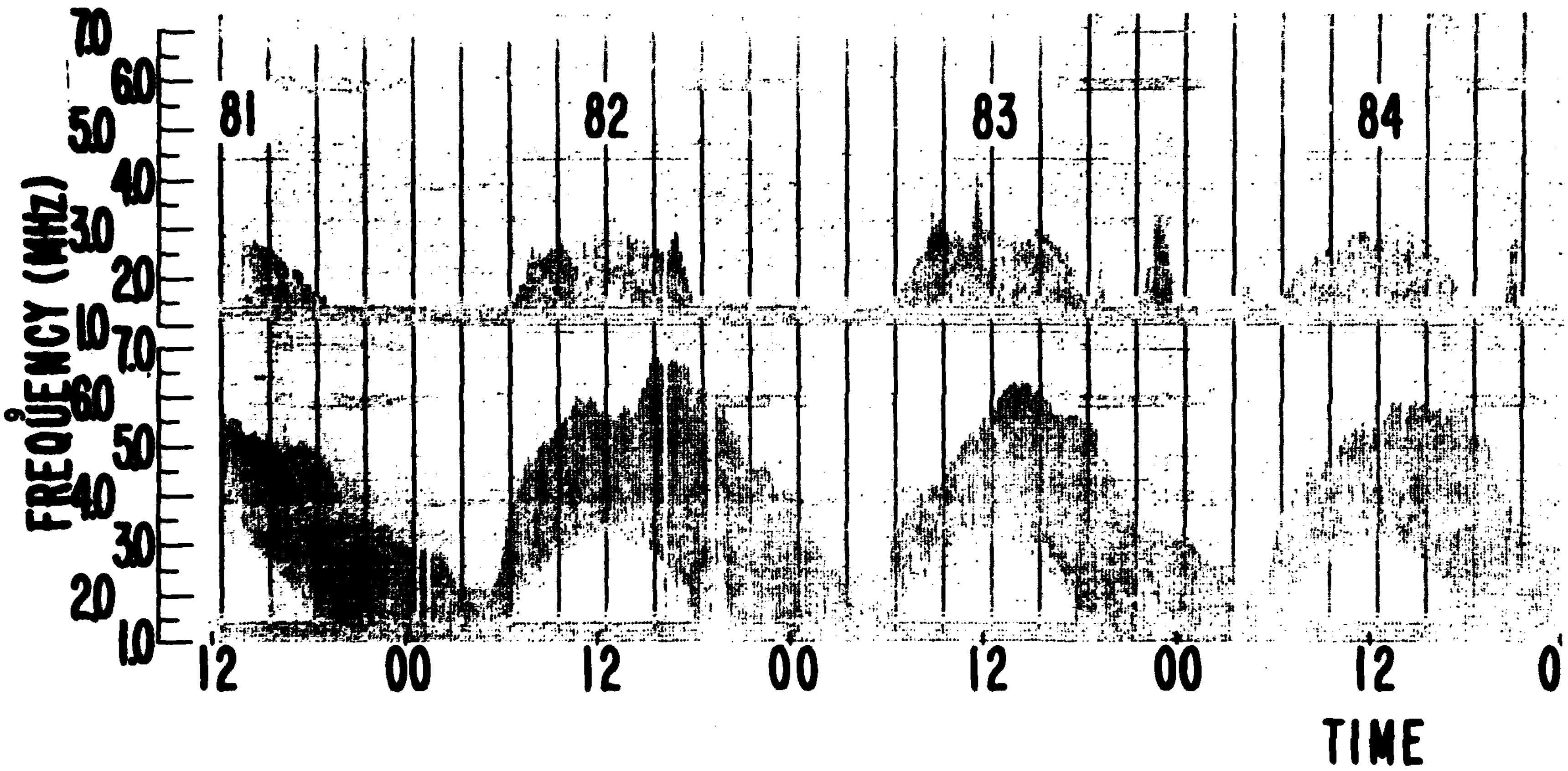
HMAX = 395.7 KM AND NMAX = 0.2370+07 EL/CC.

THE RATIO OF THE LAST TWO SLOPES IS 0.879

ALT.	DENSITY	ALT.	DENSITY	ALT.	DENSITY	ALT.	DENSITY
290.0	0.181E+07	300.0	0.191E+07	310.0	0.200E+07	320.0	0.208E+07
330.0	0.215E+07	340.0	0.222E+07	350.0	0.227E+07	360.0	0.231E+07
370.0	0.234E+07	380.0	0.236E+07				

STOP

Fig. 2 Computer print-out of computed N(h) profile, 19 Oct 77, 1240 EST.



<u>Fig. 3</u>

Diurnal variation of <u>E</u>- (top) and <u>F</u>- (bottom)—layer usable frequencies, March 22-28, 1978. Abscissa indicates time at 15-minute intervals, ordinate indicates frequency. Numerical characters indicate relative signal amplitudes at the various frequencies.

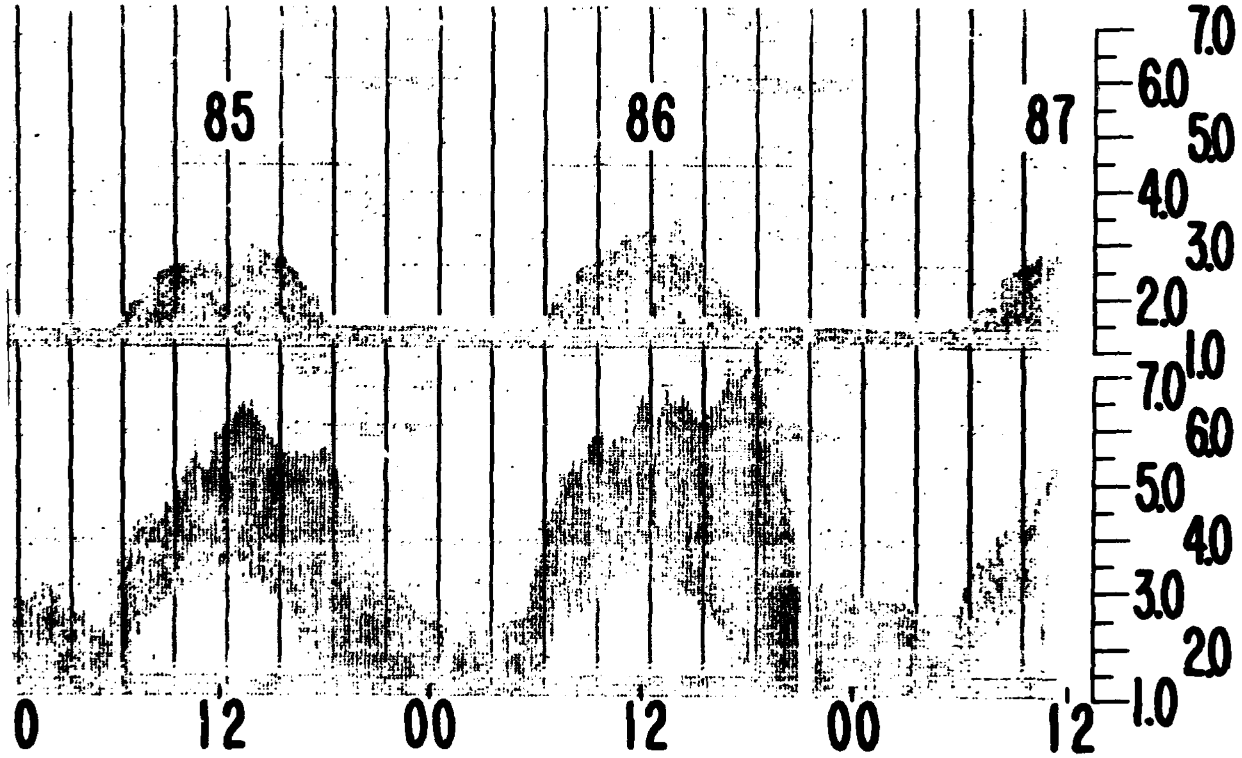
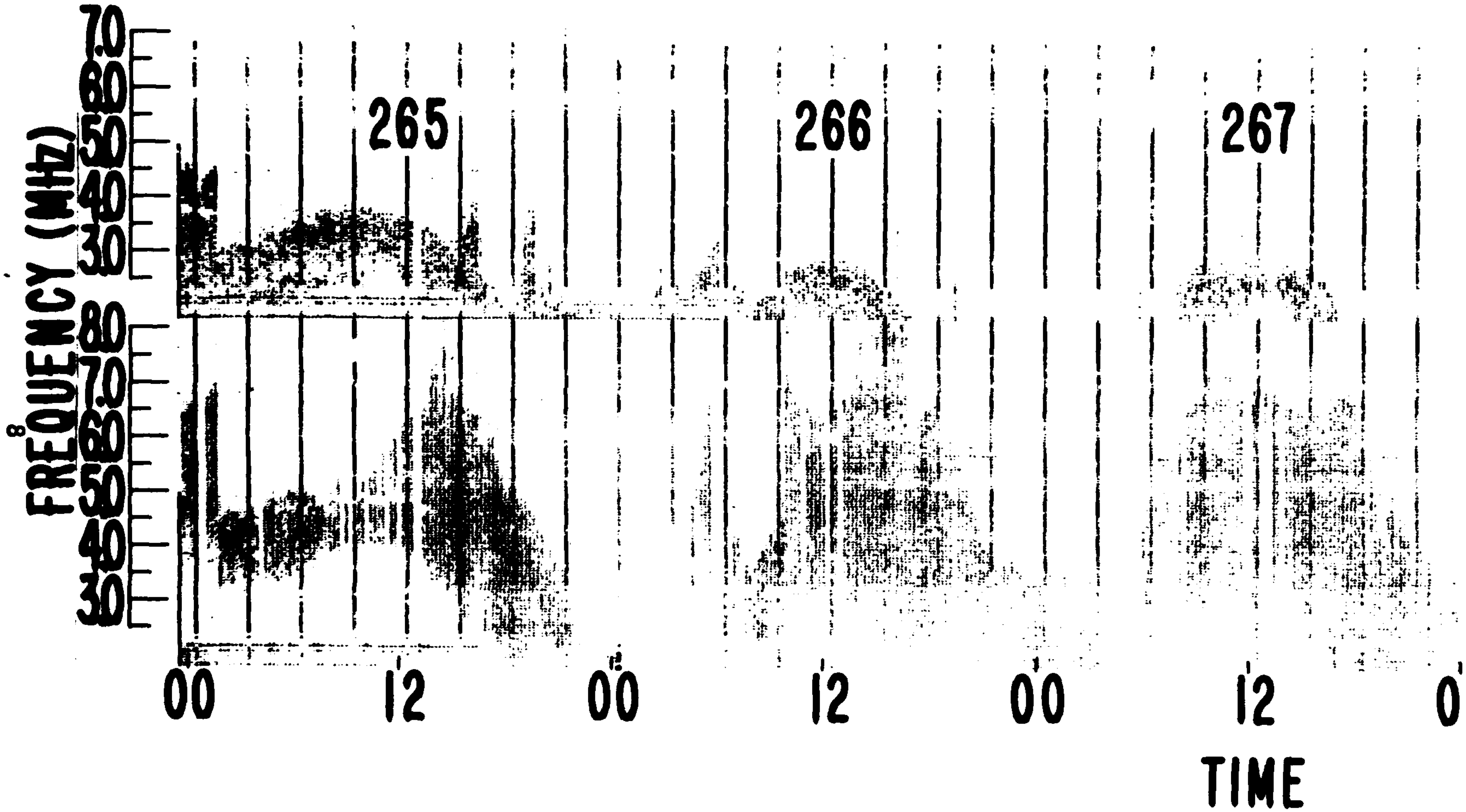


Fig. 3 (Cont'd)



<u>Fig. 4</u>

Same as Fig. 3, but for the time period. 21-26 September 1977.

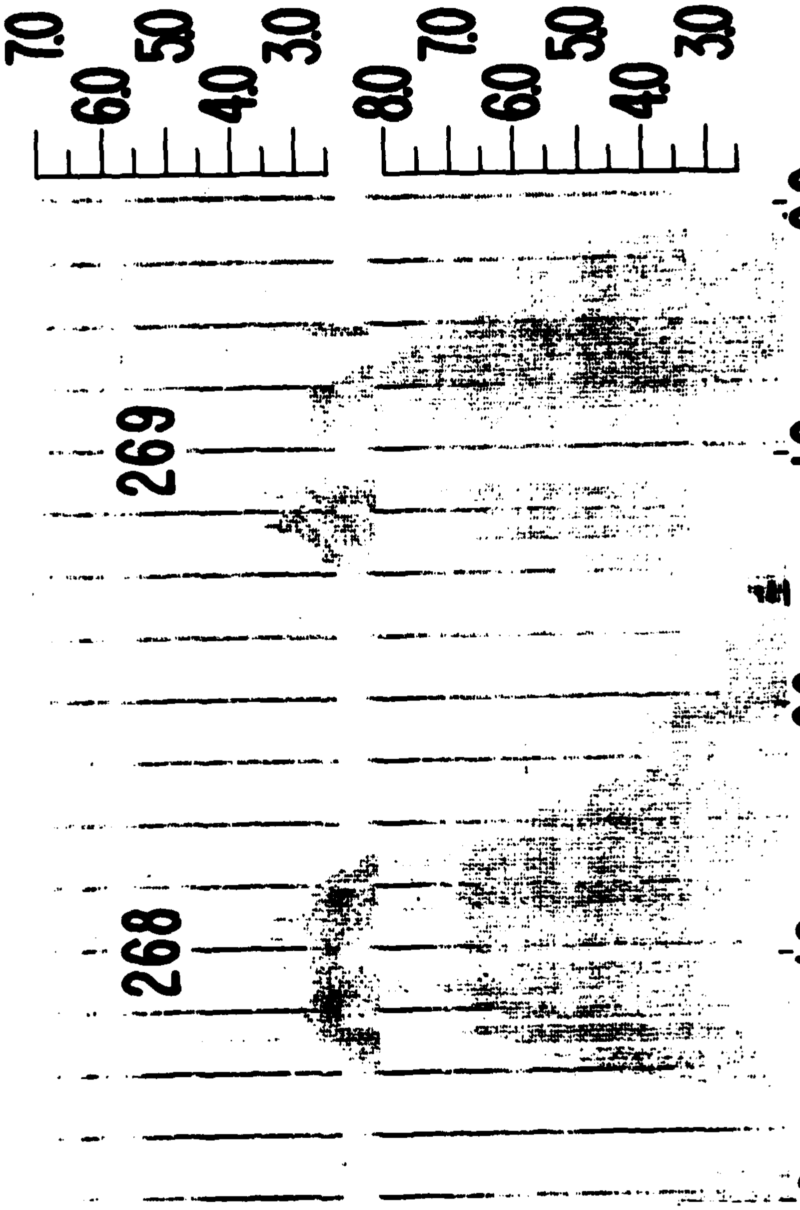


Fig. 4 (Cont'd)